

COMPARISON OF IRON UPTAKE BY BEAN ROOT AND LEAF TISSUES

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ABSTRACT

An attempt was made to find an explanation for the observed difference in uptake between root and leaf tissues of the bean plant, viz., higher uptake by root tips than by leaf discs in spite of a similar pattern of uptake by the two tissues.

Although leaf slices absorbed more Fe than leaf discs, the absorption was still considerably lower than by root tips. Fe absorption by enzymically isolated root and leaf cells also reflected the observed difference in uptake between root and leaf tissues.

It appears unlikely that the lower Fe uptake by leaf discs in comparison to that by root tips is related to structural aspects of the tissues.

UITTREKSEL

WORTEL- VERSUS BLAAROPNAME VAN YSTER DEUR DIE WEEFSELS VAN DIE BOONTJIEPLANT

Daar is gepoog om 'n verklaring te vind vir die waargenome verskil in opname tussen wortel- en blaarweefsels van die boontjieplant, nl., hoër opname deur wortelpunte as deur blaarskyfies ten spyte daarvan dat die patroon van opname deur die twee weefsels deurgaans dieselfde was.

Fe-opname deur blaarrepies is met opname deur blaarskyfies en wortelpunte vergelyk. Alhoewel blaarrepies meer Fe as blaarskyfies opgeneem het, was dit steeds aansienlik minder as die hoeveelheid deur die wortelpunte opgeneem. Fe-opname deur ensimatiegeïsoleerde wortel- en blaarselle het ook die waargenome verskil in opname tussen wortel- en blaarweefsel vertoon.

Dit lyk onwaarskynlik of die laer opname van Fe deur blaarskyfies in vergelyking met dié deur wortelpunte aan strukturele aspekte van die weefsels toegeskryf kan word.

INTRODUCTION

In previous work on Fe uptake by bean root and leaf tissues (Jooste and De Bruyn, 1979a, b), the pattern of absorption was similar, however root tissue absorbed considerably more Fe than leaf tissue. This raised the question whether this difference in uptake is related to structural differences or to inherent differences in uptake ability between leaf and root tissues.

By comparing Rb uptake by leaf discs, ring-shaped leaf discs, and leaf slices, Smith and Epstein (1964a) found that absorption per unit mass decreased with increased size of the tissue pieces. From this they concluded that in the larger pieces of tissue an increased percentage of the cells were not involved in absorption from the medium; only the boundary cells were capable of doing so.

A comparison of the rate of K absorption by barley roots and corn leaf tissue produced similar results (Smith and Epstein, 1964b). From this they concluded that the carriers involved in K absorption are identical in barley roots and corn leaves.

Jacoby and Plessner (1970) determined that chloride absorption by bean leaves at fairly low external concentrations amounts to approximately one-sixth of the amount absorbed by roots of the same plant. They, however, did not attempt to explain these differences.

Fe uptake by excised rice roots (Kannan, 1971) and isolated tobacco leaf cells (Kannan, 1969; Kannan and Wittwer, 1967) were studied, but Fe uptake by leaf and root tissues of the same species have not been compared.

In view of the foregoing, an attempt was made to find an explanation for the observed difference in uptake between root and leaf tissues of bean.

MATERIAL AND METHODS

The two youngest fully expanded leaves and excised root tips from bean plants (*Phaseolus vulgaris* L., cv. Top Crop) grown as previously described (Jooste and De Bruyn, 1979a) were used as experimental material.

Two experiments were conducted. In the first experiment, Fe uptake by leaf discs (5 mm diameter) and root tips (10–15 mm long) was compared to uptake by leaf slices, 2 mm wide and cut from leaves of which the main veins had been removed. An equal fresh mass (c. 0.23 g) of leaf discs, leaf slices, and root tips were placed in nylon gauze bags with 3 compartments, which were thereupon placed in the experimental solution.

The experimental solution contained 5 mg l^{-1} Fe (as $FeCl_3$) in 0.5 mM $CaCl_2$ solution adjusted to pH 3.2, and aerated while maintained at 30 °C. Following absorption periods of 30 and 120 minutes, half of the samples were subjected to a desorption treatment in 10 mM Na_2 -EDTA at 2 °C for 30 minutes.

In the second experiment, Fe absorption by enzymically isolated root and leaf cells was investigated. A modification of the method of Jyung, Wittwer and Bukovac (1965), for the separation of cells, was followed. Slices, 2 mm wide, were cut from leaves; root tips were cut into segments of 2 mm. Because preliminary trials showed that separated root cells could not be obtained easily, and the above authors also indicated that difficulty is experienced in isolating cells from bean roots, the root segments were lightly crushed between two glass plates. The concentration of pectinase (Sigma Chemical Company) in the separation medium was doubled to 0.4 %, and an acetic acid-sodium acetate buffer at pH 4.0 instead of a tris maleate buffer at pH 6.4, was used. In addition the separation medium contained the following: glycerol—0.2 %, peptone—0.2 %, sucrose—0.1 M, EDTA—0.02 M, K-citrate—0.01 M, and Na-succinate—0.01 M.

Approximately 10 g leaf slices and 20 g root segments were shaken in the separation medium for 90 minutes. (Less material and shorter periods yielded

unsatisfactory results.) The supernatant was decanted through fine nylon gauze and centrifuged at $350 \times g$ for 20 minutes. Cold 0,35 M sucrose solution was added to the residue and centrifugation at $350 \times g$ for 20 minutes was repeated. After microscopic examination, 0,5 g root cells and 1 g leaf cells were each made up to 50 ml with 0,35 M sucrose solution. From these suspensions 5 ml per sample were added to the experimental solution in the Fe uptake studies.

The experimental solution contained the following: 5 mg l^{-1} Fe (as $FeCl_3$), 0,5 mM $CaCl_2$, and 0,35 M sucrose. The pH was maintained at 3,2 with a glycine buffer. For each sample 25 ml of the experimental solution were used. To this was added 0,6 μCi ^{59}Fe . Absorption periods were 30 and 120 minutes.

Absorption was discontinued following centrifugation of the cells at $500 \times g$ for 20 minutes. The supernatant was decanted and 0,35 M cold sucrose solution added, followed by another centrifugation at $500 \times g$ for 20 minutes.

In both experiments the amount of absorbed Fe was determined radiometrically.

RESULTS AND DISCUSSION

Although Fe absorption was higher by leaf slices than by leaf discs (Table 1), it was still considerably less than the amount absorbed by root tips. Withdrawal of absorbed Fe by Na_2 -EDTA also occurred to about the same extent in leaf discs and leaf slices (Tables 1 and 2).

Fe absorption by isolated root and leaf cells (Table 3) still reflects the previously observed difference in uptake between root and leaf tissues. By comparing the results of Table 3 with those of Table 1, it can be calculated that separated leaf and root cells absorbed about one-fifth of the amount of Fe taken up by a corresponding fresh mass of leaf discs and root tips respectively.

In view of these findings, it appears unlikely that the lower Fe uptake by leaf discs in comparison to that by root tips, is related to structural aspects of the tissues (e.g., the presence of a cuticle in leaf tissue). The root cells apparently possess an inherently greater ability to absorb Fe than leaf cells.

In another experiment the rate of respiration of bean root tips and leaf discs was measured in a Gilson respirometer; that of the leaf tissue was found to be somewhat higher than the respiratory rate of root tissue (157 ± 3 and $134 \pm 1 \mu l g^{-1} h^{-1}$ respectively). The higher absorptive capacity of root tissue is thus not accompanied by a higher respiratory rate. The exact cause of the higher rate of Fe absorption by root cells therefore remains unresolved.

ACKNOWLEDGEMENTS

Financial assistance from the South African Department of Agricultural Technical Services and the Atomic Energy Board is gratefully acknowledged, as is the technical assistance of Mr. L. M. Raitt.

TABLE 1.
Fe content of leaf discs, leaf slices and root tips before and after desorption in 10 mM Na⁺-EDTA for 30 minutes. Fe supplied at 5 mg l⁻¹, sample size 0,23 g (fresh mass). Average of 4 replicates.

Absorption period (Min.)	Fe content (μg per sample)					
	Material		Leaf slices		Root tips	
30 120	No desorption		No desorption		No desorption	
	After desorption		After desorption		After desorption	
	8,1±0,1		11,8±0,3		44,8±1,7	
	16,7±0,6		27,7±1,8		54,0±4,3	
	4,2±0,5		7,0±0,3		17,3±1,5	
	13,3±1,1		22,3±1,0		41,6±1,1	

TABLE 2.

The ratio of Fe content of desorbed and non-desorbed tissues. Based on results in Table 1.

Absorption period (Min.)	Fe content after desorption		
	Fe content with no desorption		
	Leaf discs	Leaf slices	Root tips
30	0,52	0,59	0,39
120	0,80	0,81	0,77

TABLE 3.

Fe content of enzymically isolated leaf and root cells. Fe supplied at 5 mg l⁻¹. (Average of 4 replicates.)

Absorption period (Min.)	Fe content (μg per 0,3 g isolated cells; fresh mass)	
	Leaf cells	Root cells
30	2,1 $\pm$ 0,1	11,4 $\pm$ 0,6
120	3,2 $\pm$ 0,1	14,0 $\pm$ 0,8

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